FIG. 1

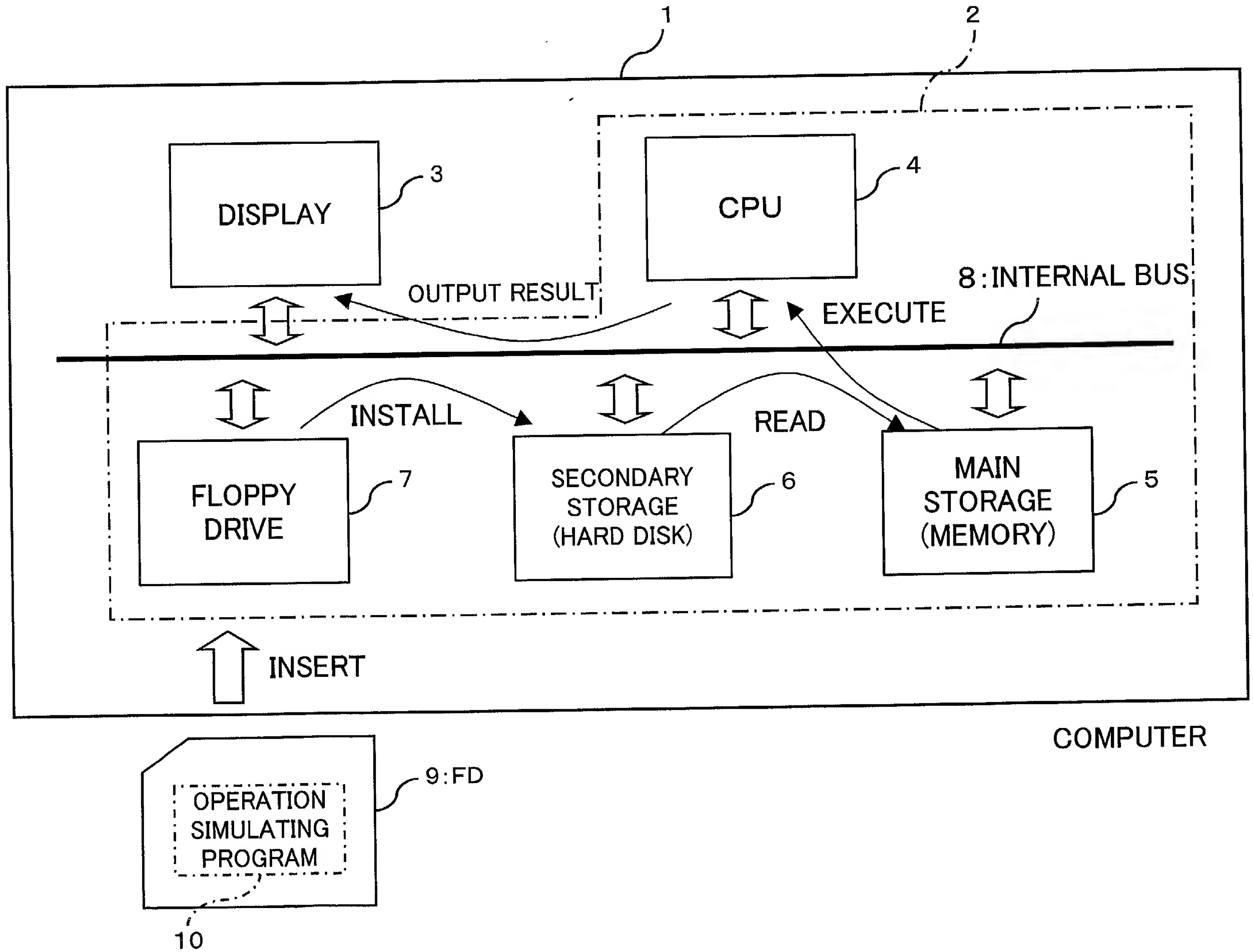
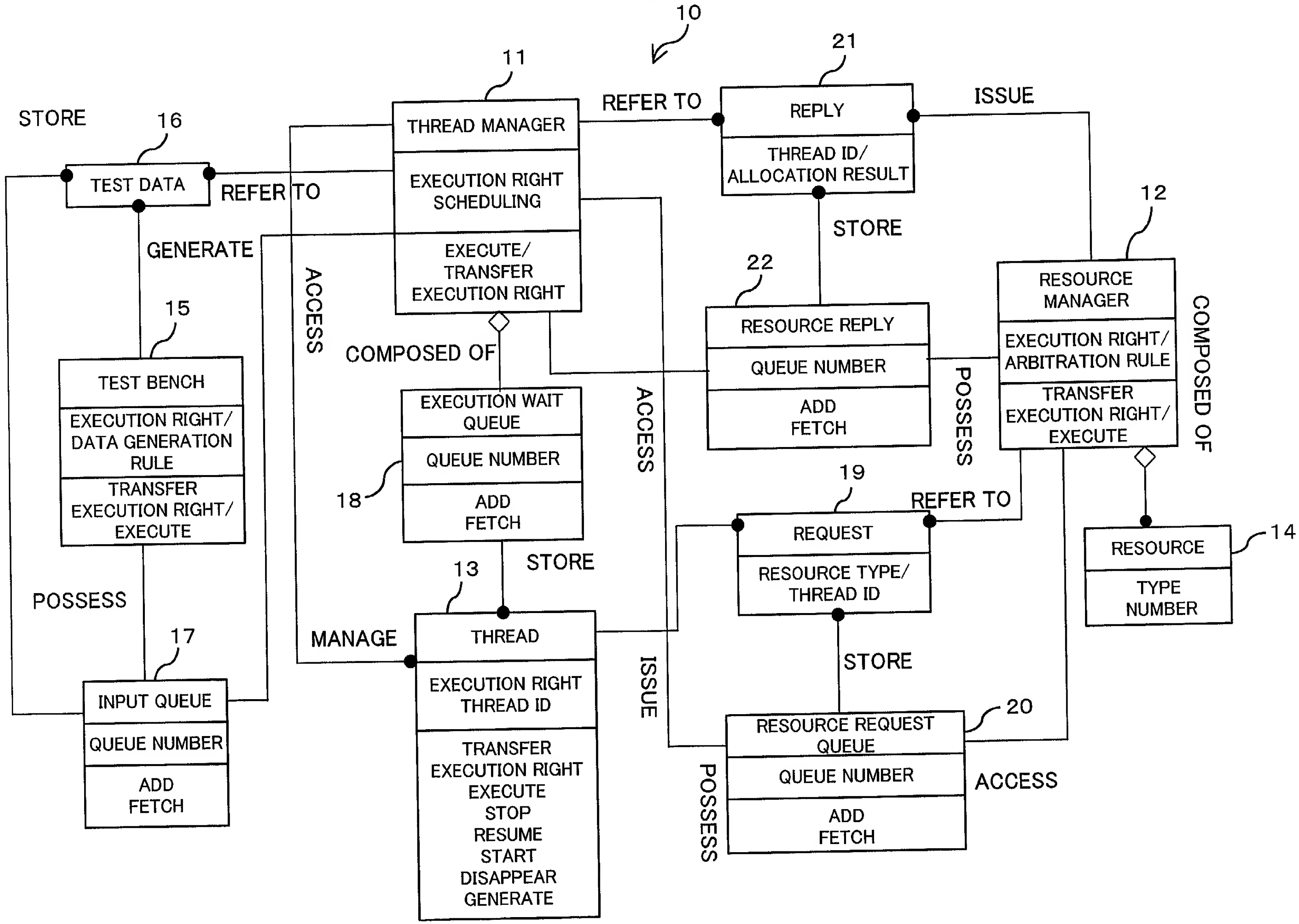

1
2
DISPLAY
3
CPU
4
OUTPUT RESULT
8:INTERNAL BUS
EXECUTE
INSTALL
READ
FLOPPY
DRIVE
7
SECONDARY
STORAGE
(HARD DISK)
6
MAIN
STORAGE
(MEMORY)
5
INSERT
COMPUTER
OPERATION
SIMULATING
PROGRAM
9:FD
10

FIG. 2



10
11
THREAD MANAGER
EXECUTION RIGHT SCHEDULING
EXECUTE/ TRANSFER EXECUTION RIGHT
REFER TO
21
REPLY
THREAD ID/ ALLOCATION RESULT
ISSUE
STORE
22
RESOURCE REPLY
QUEUE NUMBER
ADD FETCH
12
RESOURCE MANAGER
EXECUTION RIGHT/ ARBITRATION RULE
TRANSFER EXECUTION RIGHT/ EXECUTE
COMPOSED OF
14
RESOURCE
TYPE NUMBER
POSSESS
19
REQUEST
RESOURCE TYPE/ THREAD ID
REFER TO
STORE
20
RESOURCE REQUEST QUEUE
QUEUE NUMBER
ADD FETCH
ACCESS
POSSESS
ISSUE
ACCESS
13
THREAD
EXECUTION RIGHT THREAD ID
TRANSFER EXECUTION RIGHT EXECUTE STOP RESUME START DISAPPEAR GENERATE
STORE
18
EXECUTION WAIT QUEUE
QUEUE NUMBER
ADD FETCH
COMPOSED OF
ACCESS
MANAGE
STORE
16
TEST DATA
REFER TO
GENERATE
15
TEST BENCH
EXECUTION RIGHT/ DATA GENERATION RULE
TRANSFER EXECUTION RIGHT/ EXECUTE
POSSESS
17
INPUT QUEUE
QUEUE NUMBER
ADD FETCH

FIG. 3

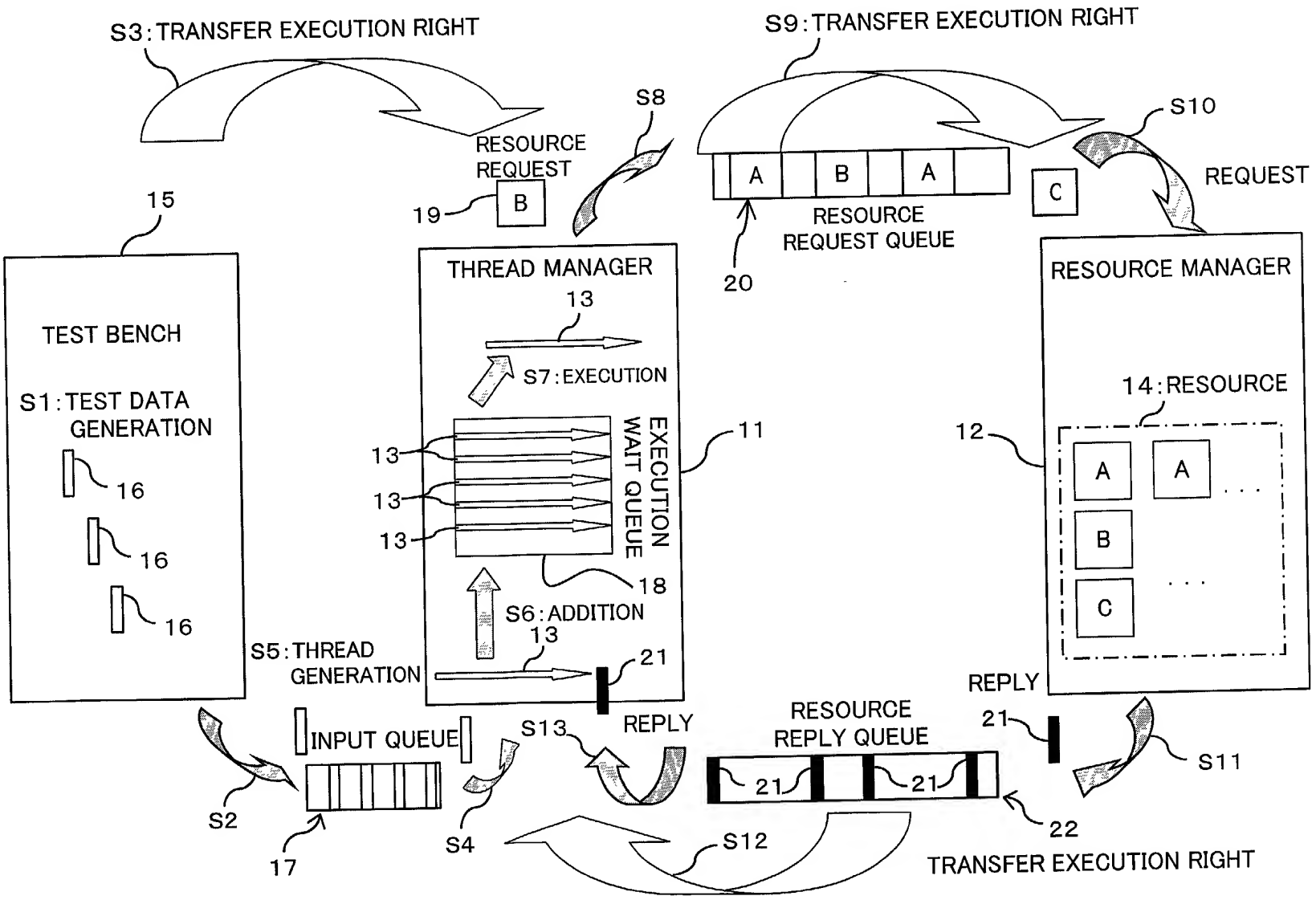

S3:TRANSFER EXECUTION RIGHT
S9:TRANSFER EXECUTION RIGHT
S8
S10
RESOURCE REQUEST
REQUEST
19
B
A
B
A
C
RESOURCE REQUEST QUEUE
20
15
TEST BENCH
S1:TEST DATA GENERATION
16
16
16
THREAD MANAGER
13
S7:EXECUTION
13
13
13
EXECUTION WAIT QUEUE
11
18
S6:ADDITION
13
S5:THREAD GENERATION
21
INPUT QUEUE
S2
17
S4
S13
REPLY
RESOURCE REPLY QUEUE
21
21
22
S12
TRANSFER EXECUTION RIGHT
RESOURCE MANAGER
14:RESOURCE
12
A
A
B
C
REPLY
21
S11

FIG. 4

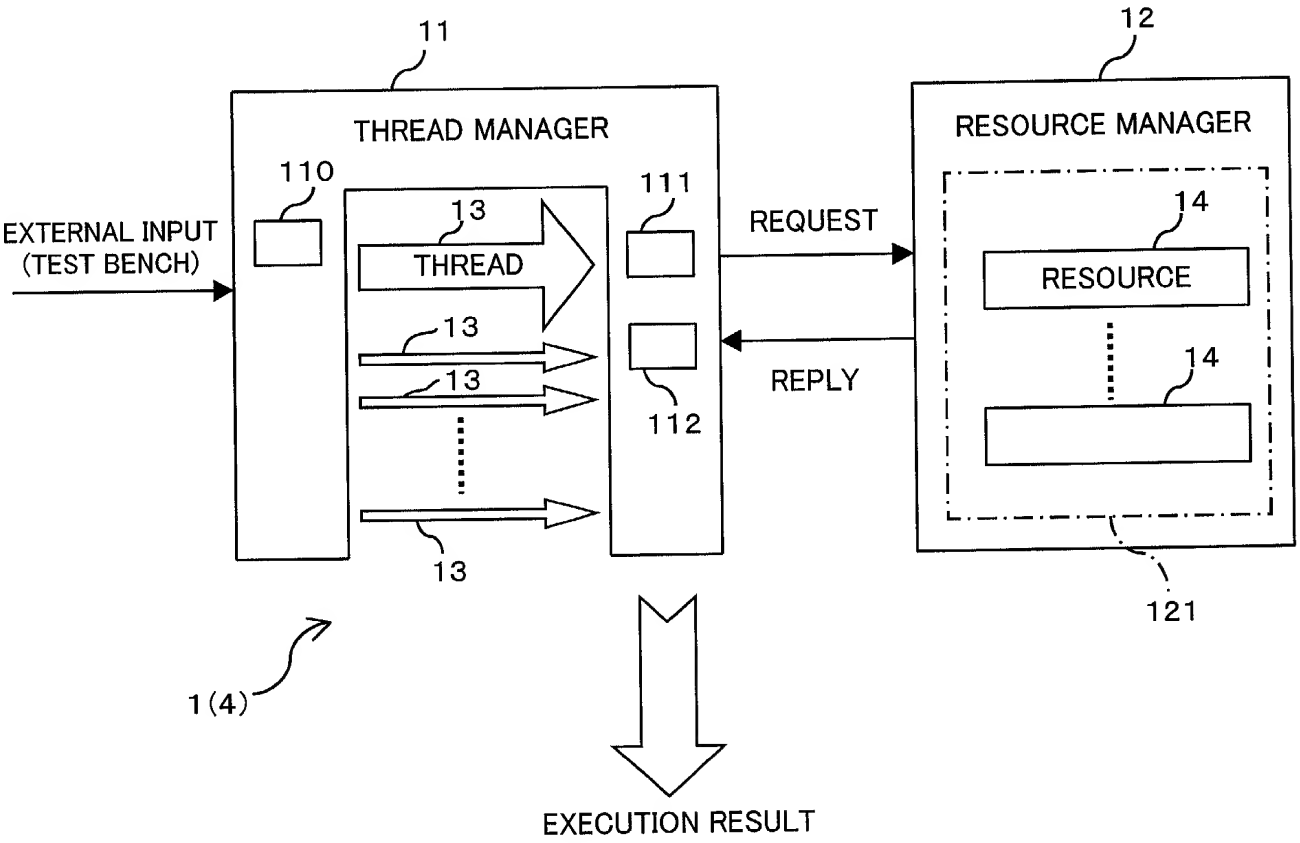

11
THREAD MANAGER
110
111
13
THREAD
13
13
13
112
EXTERNAL INPUT
(TEST BENCH)
REQUEST
REPLY
12
RESOURCE MANAGER
14
RESOURCE
14
121
1(4)
EXECUTION RESULT

FIG. 5

```
class          thread {
  ...
  void execution ( ){
    processing A ( );
    processing B ( );
    processing C ( );
  }
}
```

FIG. 6

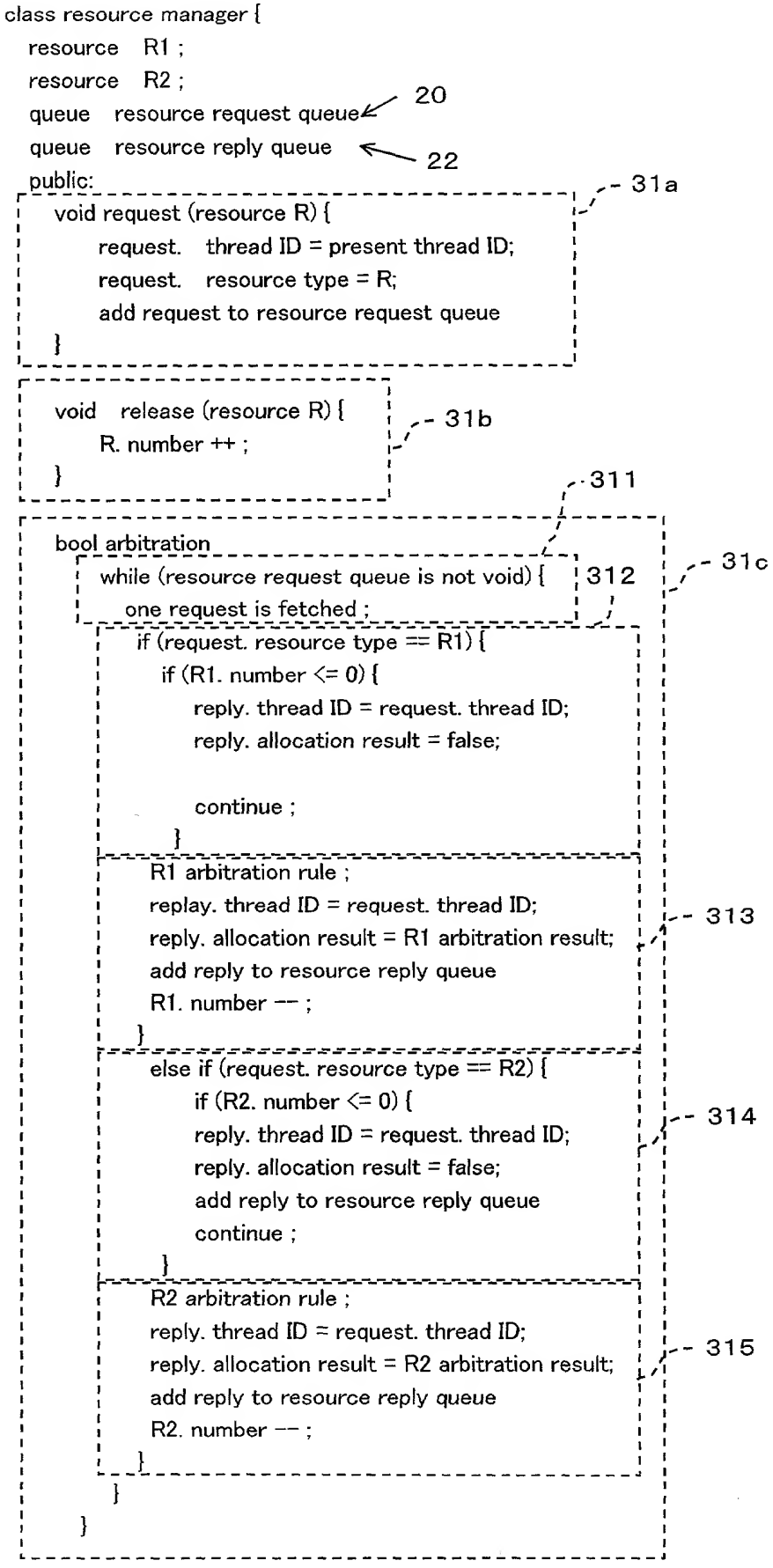

class resource manager {
resource R1 ;
resource R2 ;
queue resource request queue
queue resource reply queue
public:
20
22
31a
void request (resource R) {
request. thread ID = present thread ID;
request. resource type = R;
add request to resource request queue
}
void release (resource R) {
R. number ++ ;
}
31b
311
bool arbitration
while (resource request queue is not void) {
one request is fetched ;
312
31c
if (request. resource type == R1) {
if (R1. number <= 0) {
reply. thread ID = request. thread ID;
reply. allocation result = false;
continue ;
}
R1 arbitration rule ;
replay. thread ID = request. thread ID;
reply. allocation result = R1 arbitration result;
add reply to resource reply queue
R1. number -- ;
313
else if (request. resource type == R2) {
if (R2. number <= 0) {
reply. thread ID = request. thread ID;
reply. allocation result = false;
add reply to resource reply queue
continue ;
}
314
R2 arbitration rule ;
reply. thread ID = request. thread ID;
reply. allocation result = R2 arbitration result;
add reply to resource reply queue
R2. number -- ;
315
}
}
}

FIG. 7

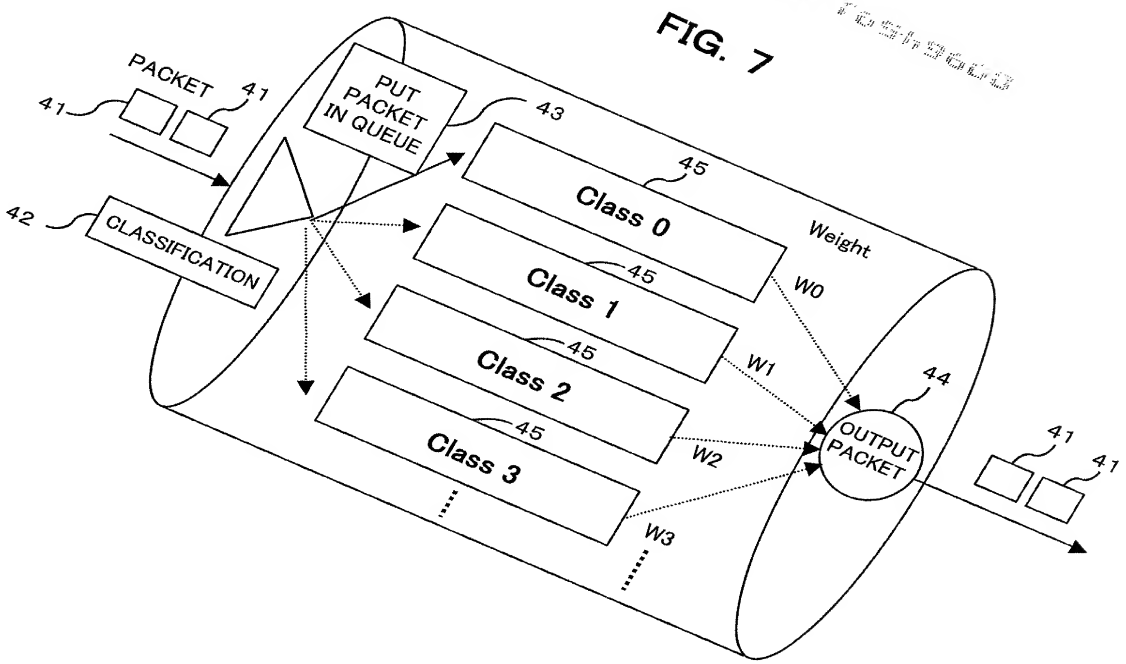

PACKET
41
41
PUT PACKET IN QUEUE
43
42
CLASSIFICATION
45
Class 0
Weight
45
Class 1
45
Class 2
45
Class 3
W0
W1
W2
W3
44
OUTPUT PACKET
41
41

FIG. 8

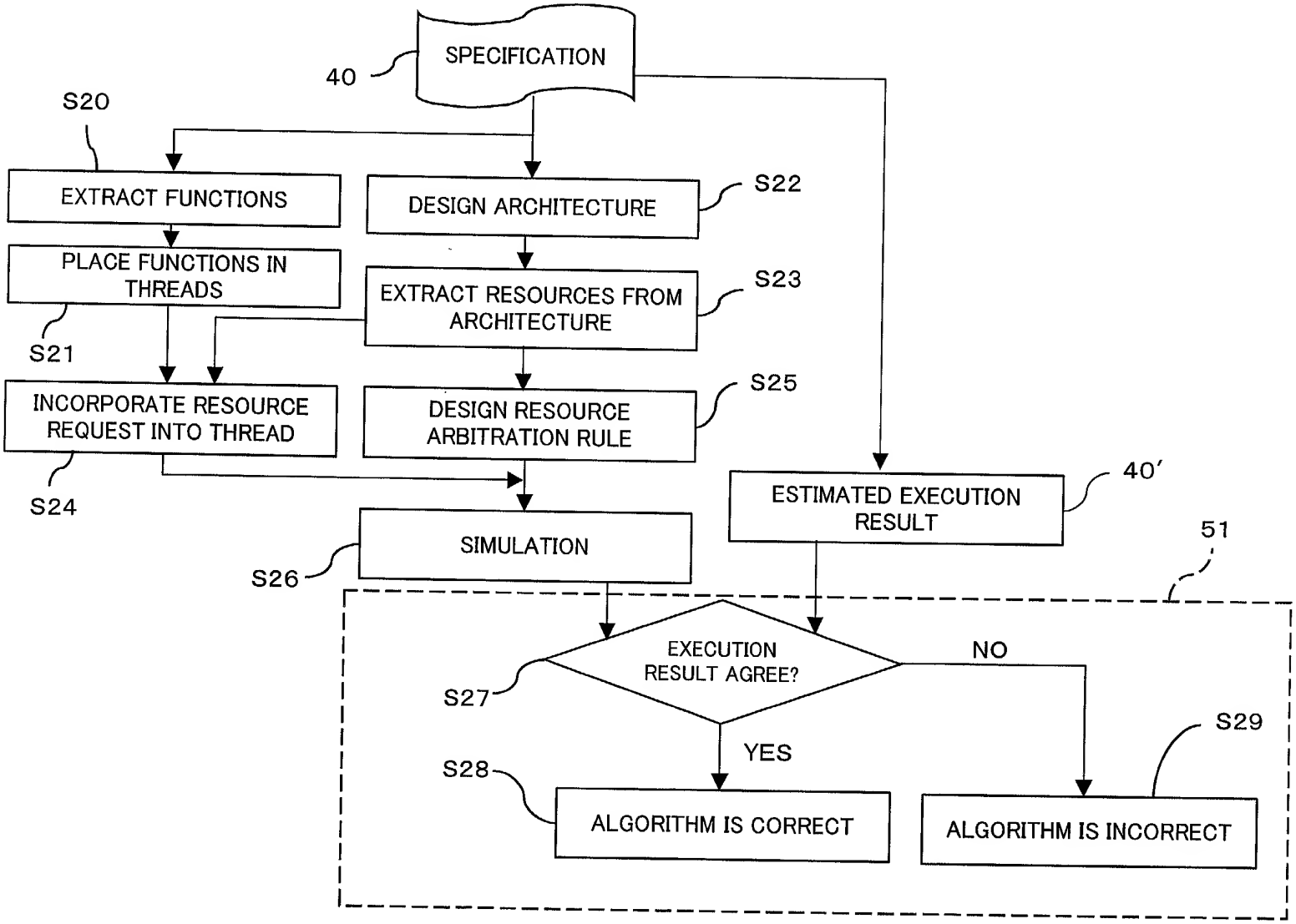


FIG. 9

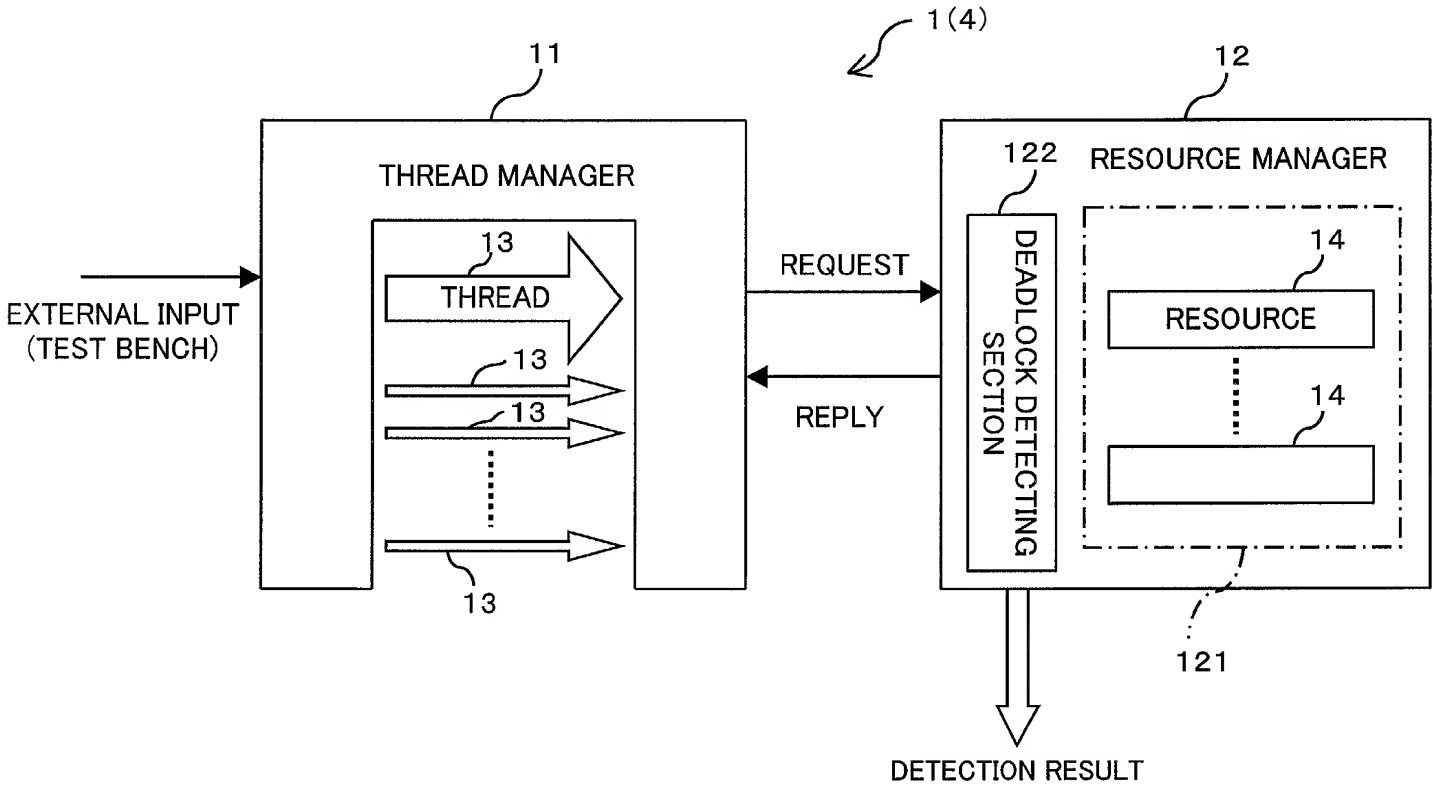

1(4)
11
12
THREAD MANAGER
122
RESOURCE MANAGER
13
THREAD
13
13
13
EXTERNAL INPUT
(TEST BENCH)
REQUEST
REPLY
DEADLOCK DETECTING SECTION
14
RESOURCE
14
121
DETECTION RESULT

FIG. 10

```
class   thread {
   ...
   void   execution ( ){
      resource A. request(2);
      processing;
      ...
resource B. request(2);
resource A. release(2);
      processing;
      ...
      resource A. request(2);
      resource B. release(2);
      processing;
      ...
      resource A. release(2);
   ...
   }
}
```

FIG. 11A

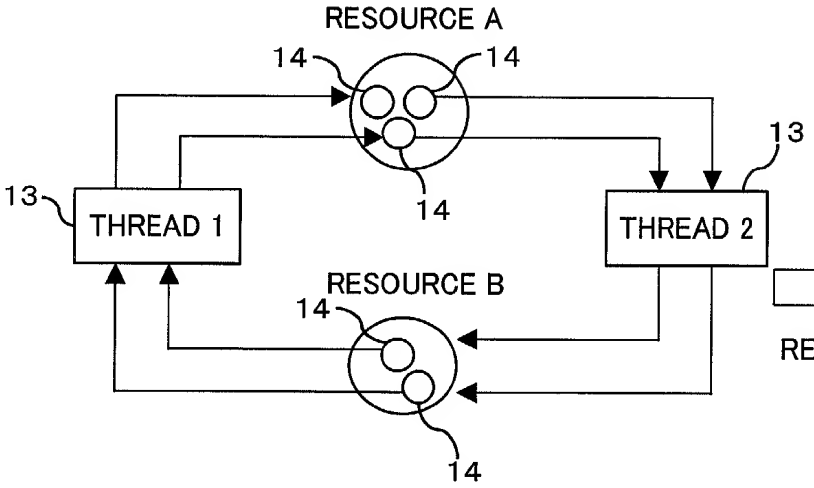


FIG. 11B

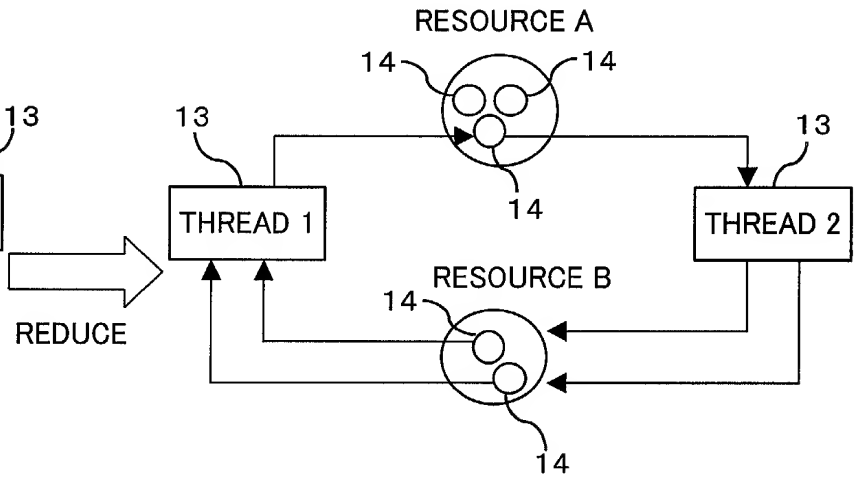


FIG. 12

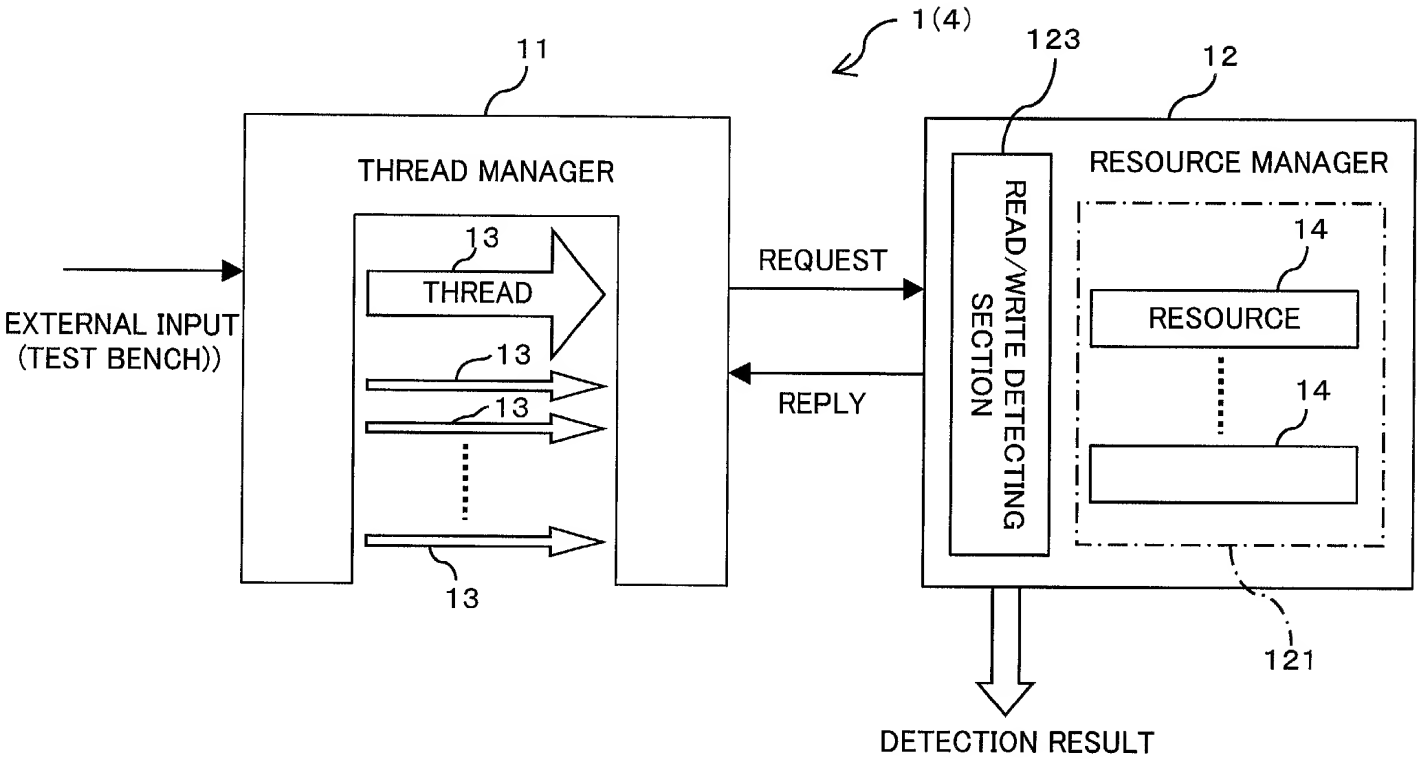

1(4)
11
123
12
THREAD MANAGER
RESOURCE MANAGER
13
THREAD
13
13
13
EXTERNAL INPUT
(TEST BENCH))
REQUEST
REPLY
READ/WRITE DETECTING SECTION
14
RESOURCE
14
121
DETECTION RESULT

FIG. 13

```
class   request {
 unsigned int   thread ID;
 int   number of requests;
 int   read/write flag;
}
```

FIG. 14

```
class   resource A : public resource {
int CurrentFlag = 0;
 ...
 void request (int n, bool ReadWriteFlage( ) {
          request. thread ID = present thread ID;
          request.   number of resources = n;
          request.   read/write flag = ReadWriteFlag;
add request to resource request queue
}
void   release (int n){                          316
       ...
       CurrentFlag = 0;
 }
 ...
bool arbitration( ) {
       ...                                                    317
 while (resource request queue is not void) {                  )
       one request is fetched;                                 )
if (CurrentFlag ! = 0 && request.   read/write flag
   != CurrentFlag){
          error ("there is possibility of occurrence of read/write error!");
        }
      CurrentFlag == request.   read/write flag;
       }
      ...
  }
  ...
}
```

FIG. 15

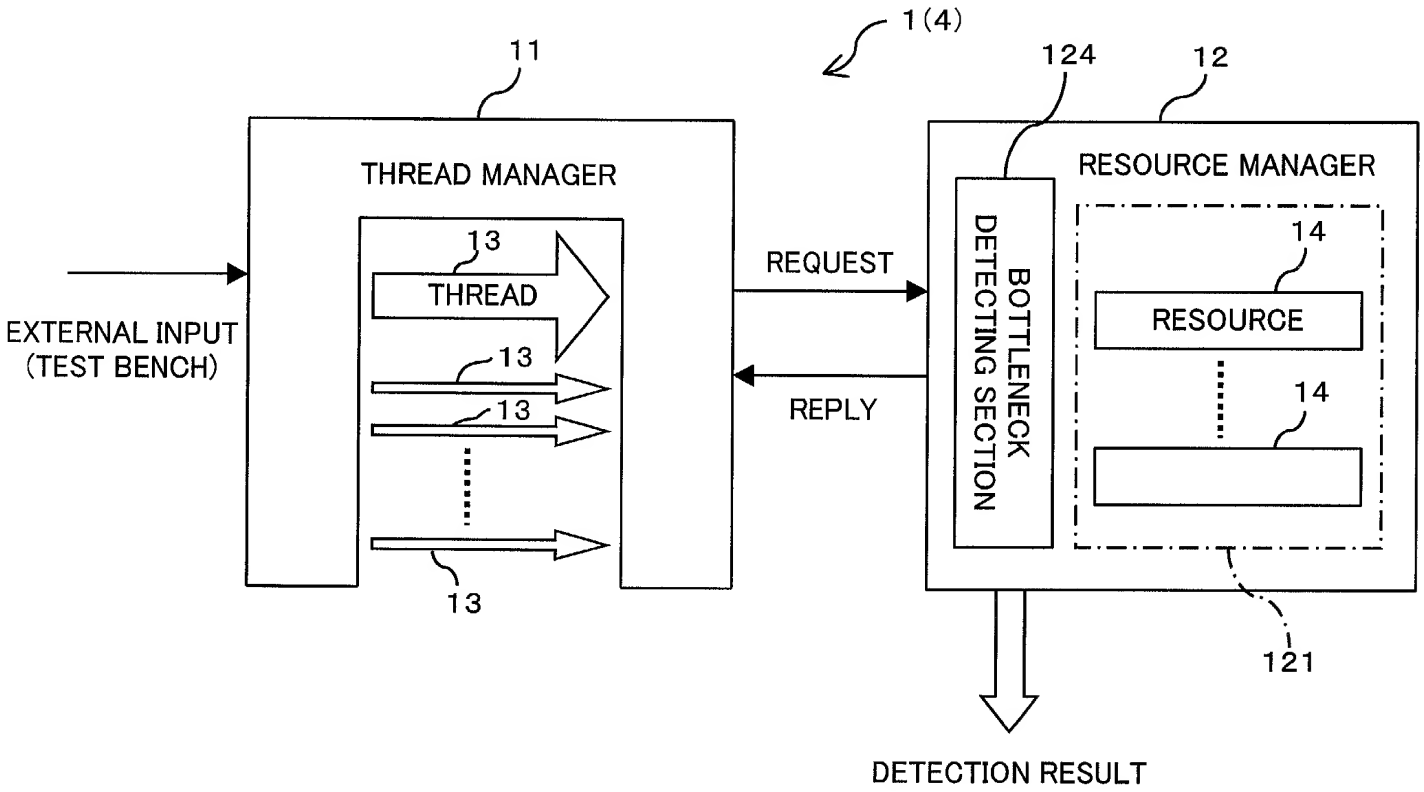

1(4)
11
124
12
THREAD MANAGER
RESOURCE MANAGER
13
THREAD
13
13
13
REQUEST
REPLY
BOTTLENECK DETECTING SECTION
14
RESOURCE
14
EXTERNAL INPUT
(TEST BENCH)
121
DETECTION RESULT

FIG. 16

```
class     resource {
   int    number of accesses = 0;
   ...
   void    request (int n) {
        number of accesses ++;
   }
   ...
   int      total of request( ) {
        return       number of accesses;
   }
}
```

FIG. 17

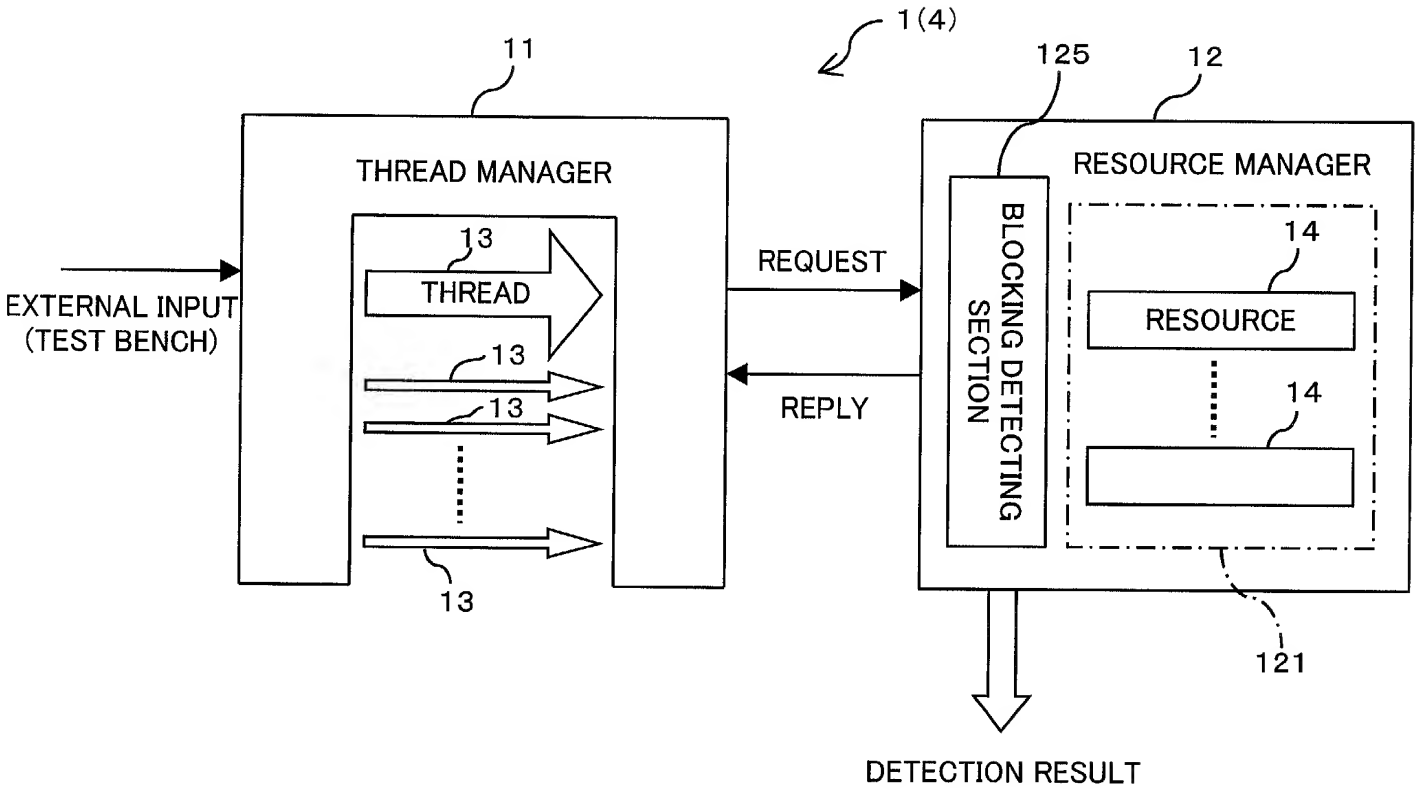

1(4)
11
125
12
THREAD MANAGER
RESOURCE MANAGER
13
THREAD
13
13
13
EXTERNAL INPUT
(TEST BENCH)
REQUEST
REPLY
BLOCKING DETECTING SECTION
14
RESOURCE
14
121
DETECTION RESULT

FIG. 18

```
class     resource A {
      ...
      bool arbitration( ) {
     while (resource request queue is not void) {
         one request is fetched;
if (number < 0) {
   error ("there is a need to block a request for resource A");
}
       }
       ...
 }
```

FIG. 19

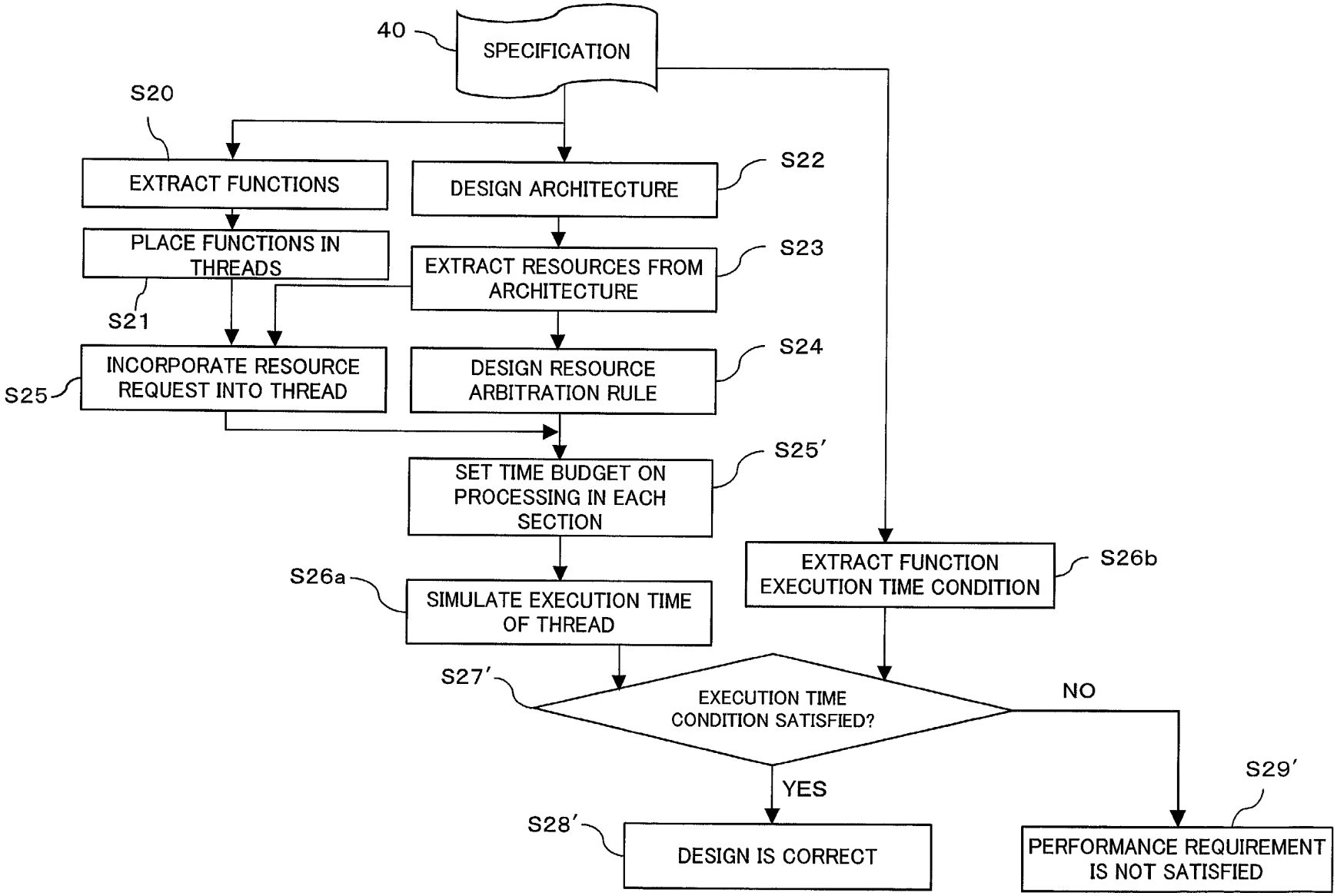

40
SPECIFICATION
S20
EXTRACT FUNCTIONS
PLACE FUNCTIONS IN THREADS
S21
INCORPORATE RESOURCE REQUEST INTO THREAD
S25
DESIGN ARCHITECTURE
S22
EXTRACT RESOURCES FROM ARCHITECTURE
S23
DESIGN RESOURCE ARBITRATION RULE
S24
SET TIME BUDGET ON PROCESSING IN EACH SECTION
S25'
S26a
SIMULATE EXECUTION TIME OF THREAD
EXTRACT FUNCTION EXECUTION TIME CONDITION
S26b
S27'
EXECUTION TIME CONDITION SATISFIED?
NO
YES
S28'
DESIGN IS CORRECT
S29'
PERFORMANCE REQUIREMENT IS NOT SATISFIED

FIG. 20

```
class   thread {
  ...
  void   execution ( ){
    resource A.   request (1);
    processing 1;
    delay (time budget for processing 1);
    resource A.   release (1);
    resource B.   request (1);
    processing 2:
    delay (time budget for processing 2);
    resource B.   release (1);
    ...
  }
}
```

FIG. 21

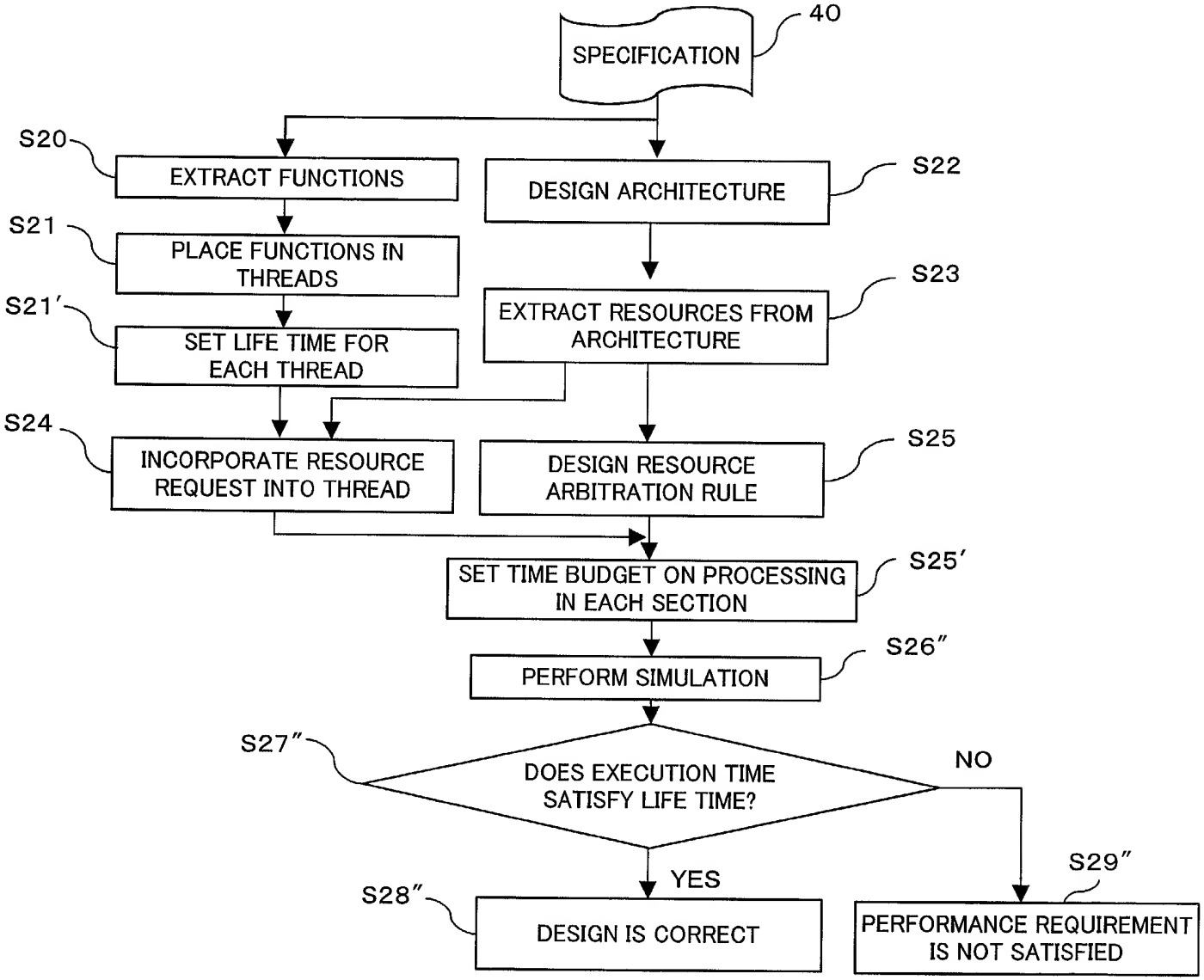

SPECIFICATION
40
S20
EXTRACT FUNCTIONS
S21
PLACE FUNCTIONS IN THREADS
S21'
SET LIFE TIME FOR EACH THREAD
S22
DESIGN ARCHITECTURE
S23
EXTRACT RESOURCES FROM ARCHITECTURE
S24
INCORPORATE RESOURCE REQUEST INTO THREAD
S25
DESIGN RESOURCE ARBITRATION RULE
S25'
SET TIME BUDGET ON PROCESSING IN EACH SECTION
S26"
PERFORM SIMULATION
S27"
DOES EXECUTION TIME SATISFY LIFE TIME?
NO
YES
S28"
DESIGN IS CORRECT
S29"
PERFORMANCE REQUIREMENT IS NOT SATISFIED

FIG. 22

```
class   thread {
        long    life time;
        long    delay;
        void    execution ( ){
                ...
        }
        bool JugdeLifeTime( ){
                if (life time < delay)
                return false;
                else        return true;
        }
}
```

FIG. 23

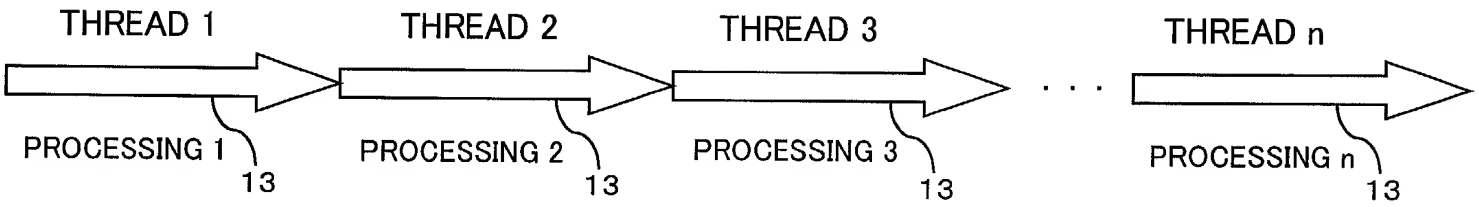

THREAD 1
THREAD 2
THREAD 3
THREAD n
PROCESSING 1
13
PROCESSING 2
13
PROCESSING 3
13
PROCESSING n
13

FIG. 24

```
class   thread {
  ...
  void   execution( ) {
    thread 1.   generate( );
    thread 1.   wait for completion( );
    thread 2.   generate( );
    thread 2.   wait for completion( );
    thread 3.   generate( );
    thread 3.   wait for completion( );
  }
}

class   thread 1: public thread {
  ...
    void   execution( ) {
    processing 1( );
   }
  ...
}
class   thread 2: public thread {
  ...
  void   execution( ) {
        processing 2( );
     }
   ...
  }

thread 3: public thread {
  ...
  void   execution( ) {
      processing 3( );
  }
  ...
}
```

FIG. 25

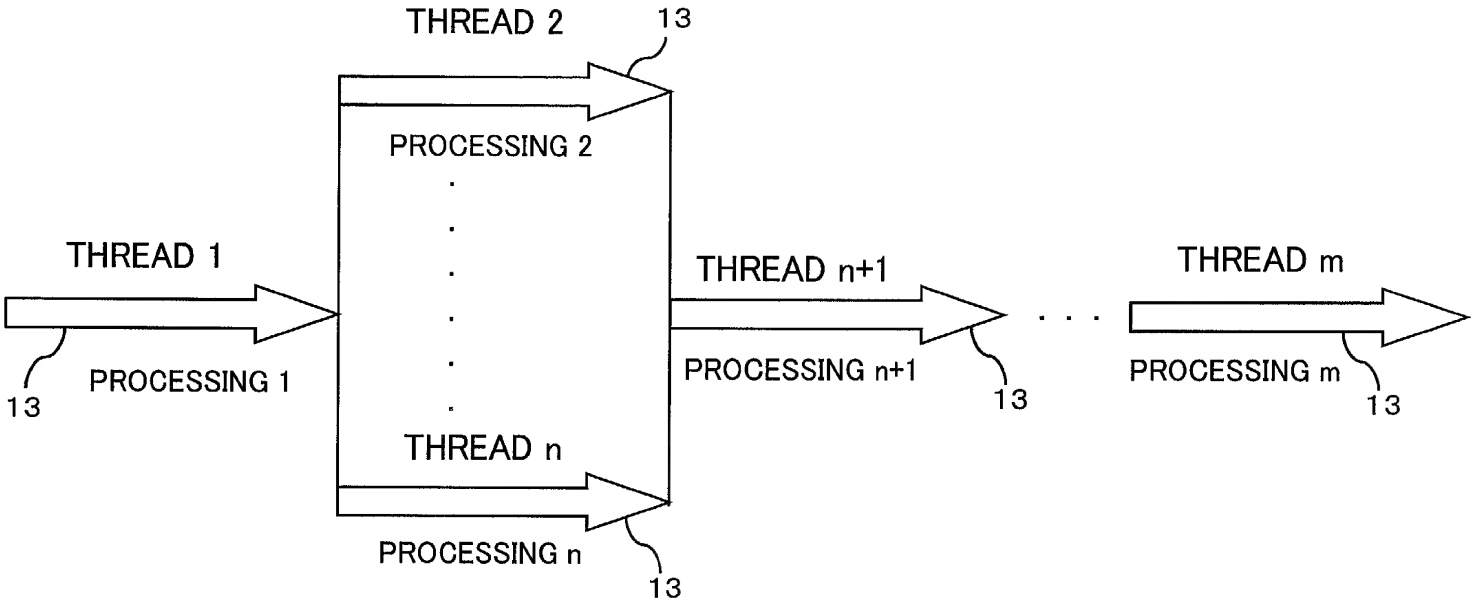

THREAD 2
13
PROCESSING 2
THREAD 1
THREAD n+1
THREAD m
PROCESSING 1
13
PROCESSING n+1
13
PROCESSING m
13
THREAD n
PROCESSING n
13

FIG. 26

```
class   thread {
  ...
  void   execution( ) {
    thread A.   generate( );
    thread B.    generate( );
    thread A.   wait for completion( );
    thread B.   wait for completion( );
    thread C.   generate( );
    thread C.   wait for completion( );
  }
}
```

FIG. 27

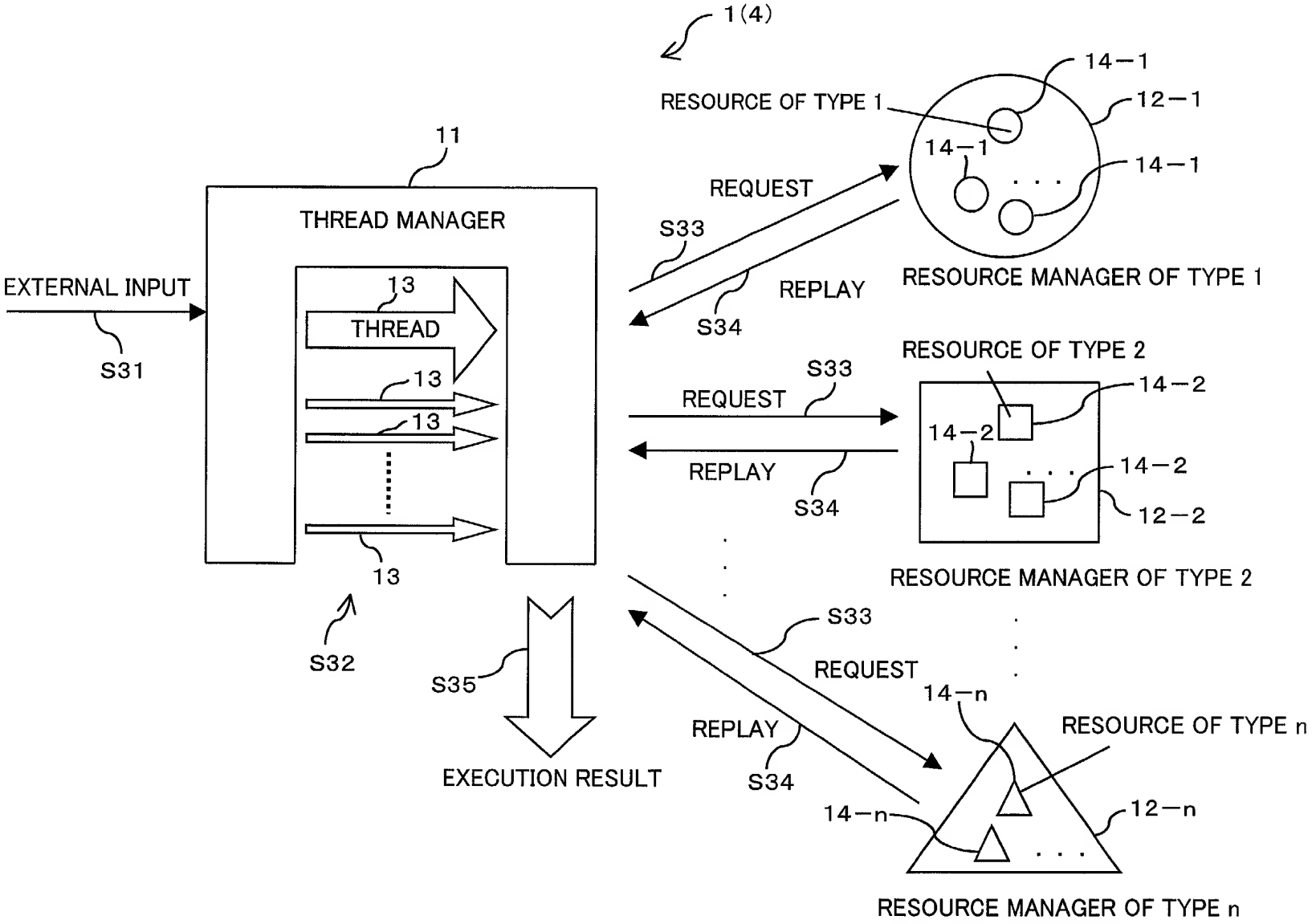

1(4)
11
THREAD MANAGER
EXTERNAL INPUT
S31
13
THREAD
13
13
13
S32
S35
EXECUTION RESULT
RESOURCE OF TYPE 1
14−1
12−1
14−1
14−1
REQUEST
S33
REPLAY
S34
RESOURCE MANAGER OF TYPE 1
RESOURCE OF TYPE 2
S33
REQUEST
REPLAY
S34
14−2
14−2
14−2
12−2
RESOURCE MANAGER OF TYPE 2
S33
REQUEST
REPLAY
S34
14−n
RESOURCE OF TYPE n
14−n
12−n
RESOURCE MANAGER OF TYPE n

FIG. 28

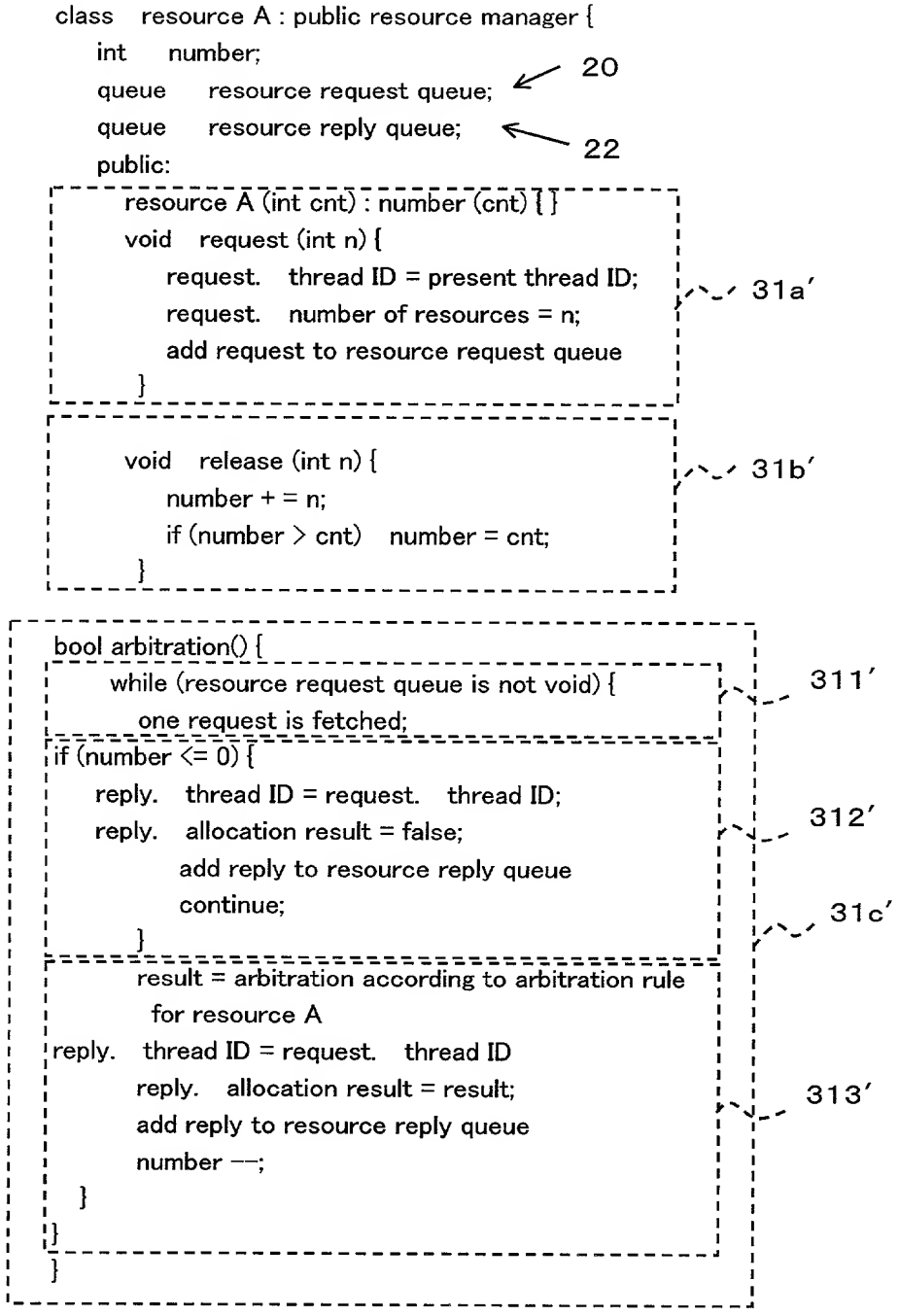

class resource A : public resource manager {
int number;
queue resource request queue;
20
queue resource reply queue;
22
public:
resource A (int cnt) : number (cnt) { }
void request (int n) {
request. thread ID = present thread ID;
request. number of resources = n;
add request to resource request queue
}
31a'
void release (int n) {
number + = n;
if (number > cnt) number = cnt;
}
31b'
bool arbitration() {
while (resource request queue is not void) {
one request is fetched;
311'
if (number <= 0) {
reply. thread ID = request. thread ID;
reply. allocation result = false;
add reply to resource reply queue
continue;
}
312'
31c'
result = arbitration according to arbitration rule
for resource A
reply. thread ID = request. thread ID
reply. allocation result = result;
add reply to resource reply queue
number --;
313'
}
}
}

FIG. 29

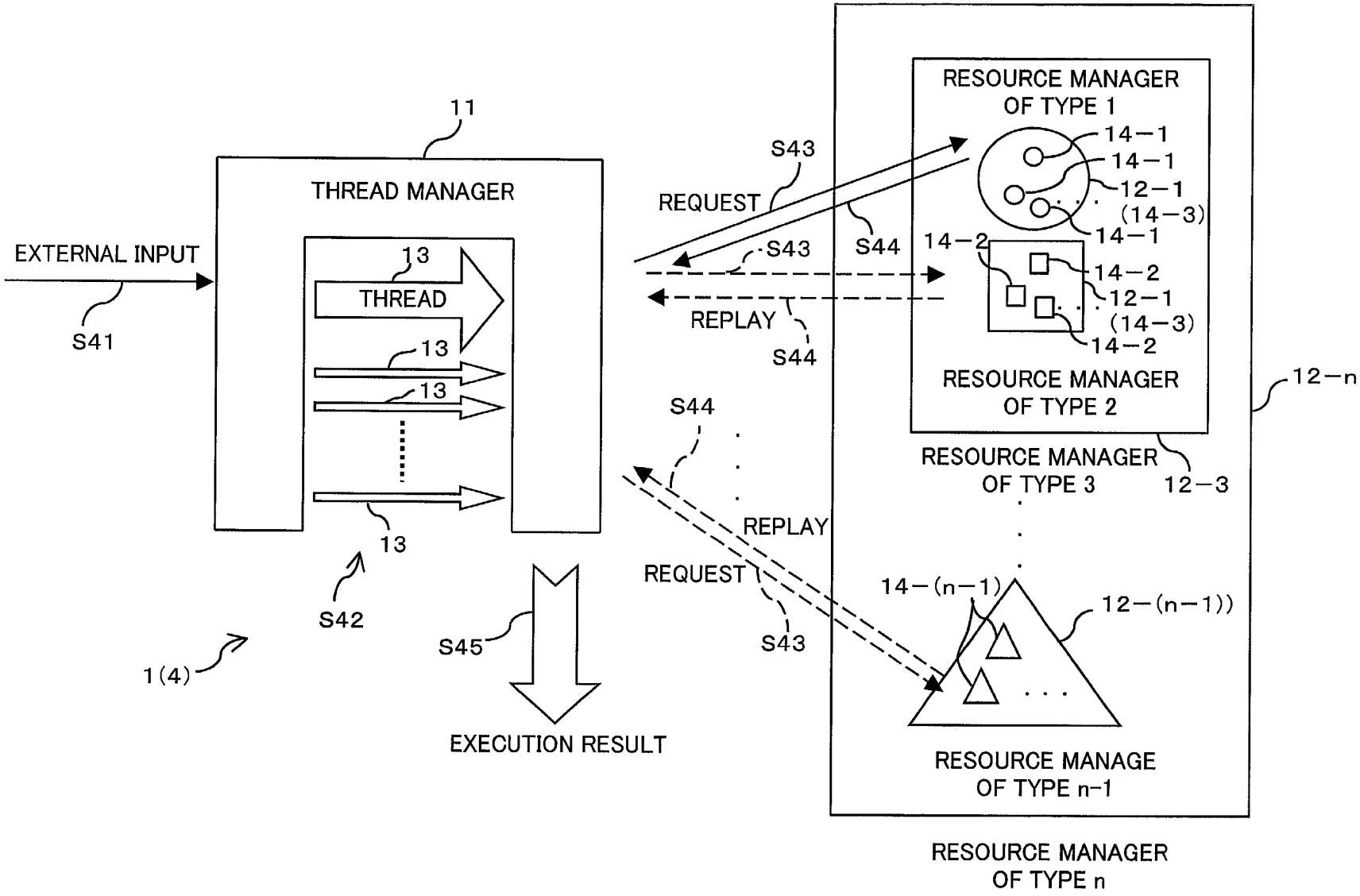

11
THREAD MANAGER
EXTERNAL INPUT
S41
13
THREAD
13
13
13
S42
1(4)
S45
EXECUTION RESULT
S43
REQUEST
S44
S43
REPLAY
S44
S44
REPLAY
REQUEST
S43
RESOURCE MANAGER
OF TYPE 1
14−1
14−1
12−1
(14−3)
14−1
14−2
14−2
12−1
(14−3)
14−2
RESOURCE MANAGER
OF TYPE 2
12−n
RESOURCE MANAGER
OF TYPE 3
12−3
14−(n−1)
12−(n−1))
RESOURCE MANAGE
OF TYPE n−1
RESOURCE MANAGER
OF TYPE n

FIG. 30A

RELATED ART

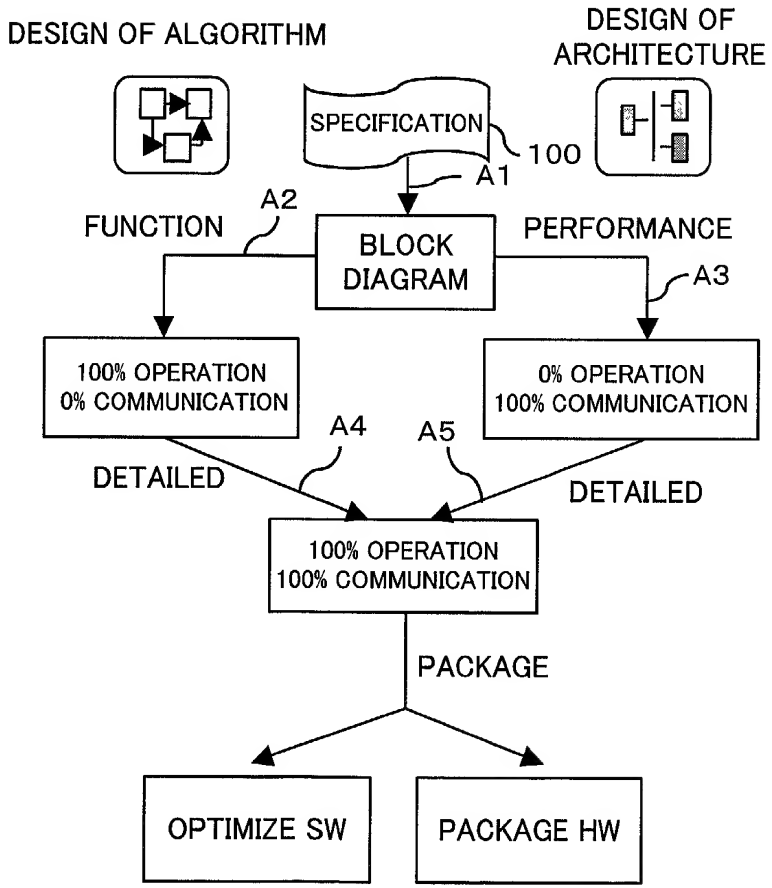


FIG. 30B

RELATED ART

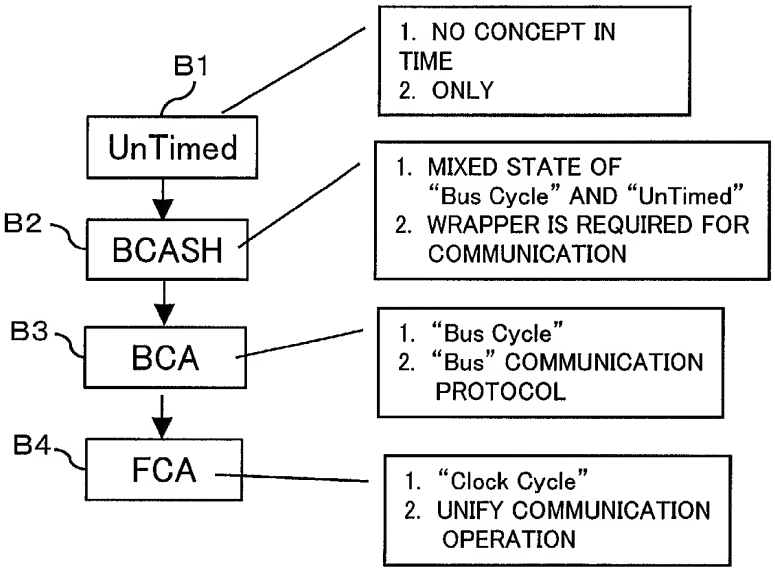


FIG. 31
RELATED ART